UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
08/988,246	12/01/97	RAOUX S	AM1771-4-T19

IM22/1103

WILLIAM L SHAFFER
PATENT COUNSEL MS/2061
LEGAL AFFAIRS DEPT. P O BOX 450A
APPLIED MATERIALS INC
SANTA CLARA CA 95052

EXAMINER	
ZERVIGON, R	
ART UNIT	PAPER NUMBER
1763	9

DATE MAILED: 11/03/99

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

Office Action Summary	Application No. 08/988,246	Applicant(s) Sebastlen et al
	Examiner Rudy Zervigon	Group Art Unit 1763

☒ Responsive to communication(s) filed on *Oct 7, 1999*

☐ This action is **FINAL.**

☐ Since this application is in condition for allowance except for formal matters, **prosecution as to the merits is closed** in accordance with the practice under *Ex parte Quayle* 1935 C.D. 11; 453 O.G. 213.

A shortened statutory period for response to this action is set to expire *3* month(s), or thirty days, whichever is longer, from the mailing date of this communication. Failure to respond within the period for response will cause the application to become abandoned. (35 U.S.C. § 133). Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

Disposition of Claim

☒ Claim(s) *3-6, 11-14, and 16-21* is/are pending in the applicat

Of the above, claim(s) ______ is/are withdrawn from consideration

☐ Claim(s) ______ is/are allowed.

☒ Claim(s) *3-6, 11-14, 17-19, and 21* is/are rejected.

☒ Claim(s) *16 and 20* is/are objected to.

☐ Claims ______ are subject to restriction or election requirement.

Application Papers

☐ See the attached Notice of Draftsperson's Patent Drawing Review, PTO-948.

☐ The drawing(s) filed on ______ is/are objected to by the Examiner.

☐ The proposed drawing correction, filed on ______ is ☐ approved ☐ disapproved.

☐ The specification is objected to by the Examiner.

☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).

☐ All ☐ Some* ☐ None of the CERTIFIED copies of the priority documents have been

☐ received.

☐ received in Application No. (Series Code/Serial Number) ______.

☐ received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

*Certified copies not received: ______

☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

Attachment(s)

☐ Notice of References Cited, PTO-892

☒ Information Disclosure Statement(s), PTO-1449, Paper No(s). *8*

☐ Interview Summary, PTO-413

☐ Notice of Draftsperson's Patent Drawing Review, PTO-948

☐ Notice of Informal Patent Application, PTO-152

--- SEE OFFICE ACTION ON THE FOLLOWING PAGES ---

#13

DETAILED ACTION

Response to Arguments

1. The argument that "Bialko does not describe an impedance monitor coupled to low and high frequency electrodes" is identified. However, the examiner disagrees with applicant's contention that "Patrick et al teach a power sensor 206 connected only to the top electrode". There is no citation made by applicant from the Patrick et al reference supporting "a power sensor 206 connected only to the top electrode", where, as in the first two office actions, there is clearly stated evidence that Patrick et al provide impedance measures between two electrodes:

The Patrick et al sensor may also measure the voltage, current and phase angle at the chamber electrode, *and measure the chamber impedance as desired*. In addition, Patrick et al describe a radio frequency ("RF") generator 102 as shown in Figure 2A is coupled to a plasma chamber 104 through a matching network 120 consisting of *variable capacitors* 106 and 108, and coil 110. The plasma chamber 104 includes *a second RF electrode* 112 and a *first substrate holder that positions the substrate in the reaction zone while supporting the substrate atop a first RF electrode* 114. a *substrate* 116 is in planar communication with *the substrate holder that positions the substrate in the reaction zone while supporting the substrate atop a first RF electrode* 114. An RF excitation is created between *a second RF electrode* 112 and a *first substrate holder that positions the substrate in the reaction zone while supporting the substrate atop a first RF electrode* 114, and when a process gas or gases (not illustrated) is introduced into the plasma chamber 104, the gas turns into a plasma.

(Column 6, lines 59-67; column 4, lines 19-28; Figure 2A - solid electrical transmission lines between the upper chamber electrode 112, RF power supply, and lower electrode 114).

2. In response to applicant's argument that Provence et al and Bialko et al are nonanalogous art, it has been held that a prior art reference must either be in the field of applicant's endeavor or, if not, then be reasonably pertinent to the particular problem with which the applicant was concerned, in order to be relied upon as a basis for rejection of the claimed invention. See *In re Oetiker*, 977 F.2d 1443, 24 USPQ2d 1443 (Fed. Cir. 1992). In this case, the Provence et al and Bialko et al patent are both in the field of applicant's endeavor and reasonably pertinent to the particular problem with which the applicant was concerned namely adjusting plasma conditions in real-time process control.

3. In response to applicant's argument that the examiner's conclusion of obviousness is based upon improper hindsight reasoning, it must be recognized that **any judgment on obviousness is in a sense necessarily a reconstruction based upon hindsight reasoning**. But so long as it takes into account only knowledge which was **within the level of ordinary skill at the time the claimed invention was made**, and does not include knowledge gleaned only from the applicant's disclosure, such a reconstruction is proper. See *In re McLaughlin*, 443 F.2d 1392, 170 USPQ 209 (CCPA 1971).

Claim Rejections - 35 USC § 103

4. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

5. Claims 11-14,3,4,6,16-23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Salimian et al (U.S.Pat. 5,656,123) in view of Patrick et al (U.S.Pat. 5,474,648) and Kinoshita et al (U.S.Pat. 5,795,452), Maher et al (U.S.Pat. 5,248,371), Tadahiro Ohmi (U.S.Pat. 5,272,417). Salimian et al describe a plasma reactor suited to <u>both</u> additive and subtractive processes (column 1, lines 5-17). Specifically, Salimian et al describe:

i. A substrate processing system (item 10, Figure 1) using a deposition chamber (item 14, Figure 1; column 5, lines 38-64) encasing a reaction zone

ii. A substrate processing system using a substrate holder as a low frequency (LF) electrode (item 46, Figure 1; column 7, lines 27-34)

iii. A gas introduction system including a gas inlet (item 44, Figure 1) for supplying one or more process gas(es) to the reaction zone

iv. A high frequency (HF) electrode (column 7, lines 27-34)

v. A plasma power source (items 12, 16, Figure 1; column 5, lines 38-45) for forming plasma within the reaction zone of the additive or subtractive reaction zone (column 1, lines 5-17)

Salimian et al do not expressly meet the claim 11 limitations of an impedance monitor electrically coupled to each of the low and high frequency electrodes. Additionally, Salimian et al do not discuss

a gas distribution system including a gas inlet manifold. Commonly in the art, a gas distribution system including a gas inlet manifold is referred to a showerhead that is customarily used as a counter electrode opposite the chamber electrode supporting the processed substrate. As such, a gas distribution system including a gas inlet manifold (showerhead) is well described in the art. The gas distribution system thus claimed is amply reflective in entire subclasses 204/432, 438/729, 118/723E, 156/345 and is demonstrated clearly by Maher et al (item 90 all figures, column 8, lines 52-65) who describes a plasma processing triode reactor (column 2, lines 41-49).

Tadahiro Ohmi additionally shadows the Salimian et al patent and complements the claim 11 limitations accordingly:

vi. A substrate processing system (Figure 1a) using a deposition chamber (item 105, Figure 1a; column 6, lines 25-38) encasing a reaction zone

vii. A substrate processing system using a substrate holder as a low frequency (LF) electrode (item 104, Figure 1a; column 6, lines 26-27)

viii. A gas introduction system including a gas inlet (item , Figure) for supplying one or more process gas(es) to the reaction zone

ix. A high frequency (HF) electrode (item 107, Figure 1a; column 6, lines 25-27)

x. A plasma power source (items 111, 110, Figure 1a; column 6, lines 63-69) for forming plasma within the reaction zone of the additive or subtractive reaction zone (column 1, lines 5-17)

Roger Patrick et al. (USPat5,474,648), as described in the first two office actions, details a dynamic control and delivery of radio frequency power in plasma process systems. **The processing is utilized to enhance the repeatability and uniformity of the process plasma. Power, voltage, current, phase, *impedance*, harmonic content and direct current bias of the radio frequency energy being delivered to the plasma chamber may be monitored at the plasma chamber and used to control or characterize the plasma load.** Dynamic pro-active control of the characteristics of the radio frequency power to the plasma chamber electrode during the formation of the plasma enhances the uniformity of the plasma (ABSTRACT).

In addition, according to the following excerpt from column 3, the claim 1 limitation of ***an impedance monitor electrically coupled to the deposition chamber to measure an impedance level* of the process plasma is explicitly met**:

> ling the radio frequency energy with a computer system. In addition, the voltage, current, phase and impedance of the plasma chamber electrode may also be measured and the measurement information used by the computer power con-

From column 4:

4

trol system of the present invention.

A control system that monitors and controls the radio frequency power at the plasma chamber electrode is illustrated in FIGS. 2A and 2B. This radio frequency power control system includes a radio frequency sensor placed closely to the plasma load electrodes in the plasma etching

In addition, according to BSUM(24), The Patrick et al sensor may also measure the voltage, current and phase angle at the chamber electrode, ***and measure the chamber impedance as desired***. In addition, Patrick et al describe a radio frequency ("RF") generator 102 as shown in Figure 2A is coupled to a plasma chamber 104 through a matching network 120 consisting of *variable capacitors* 106 and 108, **or impedance tuners**, and coil 110. **The plasma chamber 104 includes *a second RF electrode* 112 and a *first substrate holder that positions the substrate in the reaction zone while supporting the substrate atop a first RF electrode* 114**. A *substrate* 116 is in planar communication with *the substrate holder that positions the substrate in the reaction zone while supporting the substrate atop a first RF electrode* 114. An RF excitation is created between *a second RF electrode* 112 and a *first substrate holder that positions the substrate in the reaction zone while*

supporting the substrate atop a first RF electrode 114, and when a process gas or gases (not illustrated) is introduced into the plasma chamber 104, the gas turns into a plasma. The plasma reactively etches the surface of the *substrate* 116. In addition, according to DETD(4), the maximum transfer of RF power from the RF generator 102 to the plasma chamber 104 *second RF electrode* 112 and a *first substrate holder that positions the substrate in the reaction zone while supporting the substrate atop a first RF electrode* 114 results when the plasma *chamber 104 load impedance* is matched to the impedance of the RF generator 102. The values of coil 110 and *variable capacitors* 106 and 108 are selected for an appropriate impedance transformation between the RF generator 102 and the plasma chamber 104 *second RF electrode* 112 and a *first substrate holder that positions the substrate in the reaction zone while supporting the substrate atop a first RF electrode* 114. *Variable capacitors* 106 and 108 may be *automatically adjusted* by a computer processor to obtain a substantially resistive termination for the RF generator 102. The claim 3 limitation of *a computer processor communicatively coupled to an impedance monitor where the computer processor receives the measured impedance as an input the measured impedance level of the process plasma* is explicitly met according to BSUM(22):

a dynamic control of the radio frequency energy with a computer system is accomplished. In addition, the voltage, current, phase and impedance of the plasma chamber electrode may also be measured and the measurement information used by the *computer* power control system of the present invention. In addition, according to BSUM(27), the power sensor connects to a *computer* power controller that uses the sensor information to dynamically and pro-actively control the output

power of the radio frequency power generator so that a desired power profile over time is a

Patrick et al do not explicitly describe all the claim 11 limitations. Specifically, Patrick et al do not describe the following claim 11 attributes:

xi. A substrate processing system **using a substrate holder as a low frequency (LF) electrode**

xii. A high frequency (HF) electrode different from the **substrate holder as a low frequency (LF) electrode**

What Patrick et al do precisely provide, in summary, is the coupling of one power source to two counter electrodes with a measure of reactor impedance as described above. Kinoshita et al additionally describe this design (column 14, lines 12-20) as an embodiment in multiple embodiments of capacitively coupled plasma reactor designs (column 1, lines 5-15). Kinoshita et al does not provide, in the sixth embodiment, two power sources as is done in the fifth embodiment that very closely resembles the electrical orientation of the claimed components of the present invention. However, the Kinoshita et al item 17, Figure 7 component is provided as a phase shifter (column 13, line 49) not an impedance monitor as described according to item 17, Figure 7 (column 14, lines 12-20).

It is the examiner's position that a person of ordinary skill in the art at the time the invention was made would have found it obvious to modify Salimian et al plasma processing reactor in view of Patrick et al and, as demonstrated by Kinoshita et al with the common gas distribution showerhead electrode as described by Maher et al. Tadahiro Ohmi additionally anticipate collective attributes claimed in claim 11 as discussed above. By providing a chamber impedance measurement and control

as described by Patrick et al into Salimian et al's two power source capacitely coupled reactor with different frequency positions, the Salimian et al inventors would arrive at the presently claimed invention under motivation provided by Patrick et al (column 3, lines 64-68 through column 4, lines 18).

6. Claim 5 is rejected under 35 U.S.C. 103(a) as being unpatentable over Salimian et al (U.S.Pat. 5,656,123) as applied to claims 11-14,3,4,6,16-23, above, and further in view of Boys et al (U.S.Pat. 4,695,700). Boys et al, as discussed in the prior actions, describe a magnetron sputter coating apparatus controlled in response to measurements of plasma parameters to control deposition parameters (abstract). Specifically, according to DETD(11), the current supplied by source 25 to coil 21, and the voltage, as well as current supplied by DC source 37 to target cathode 15 and anode 16. Source 25 includes a current transformer (not shown) for supplying lead 44 with a DC signal proportional to the current supplied by the source to coil 21. DC plasma power source 37 includes a current transformer (not shown) for supplying to lead 46 a DC signal proportional to the current supplied by source 37 between electrodes 15 and 16. *Pressure gauge 47* supplies lead 52 with a DC signal *having a magnitude proportional to the vacuum pressure in volume 13*. Flow meter 34 supplies a DC signal to lead 35 indicative of the flow rate of working gas flowing from pressurized gas source 31 to processing volume 13. In addition, according to DETD(9), DC power sources 25 and 37 are supplied from a primary, *AC power source connected to terminal 38*. Generally, power source 25 derives a variable current that is supplied to coil 21, allowing compensation for changes in coil resistance due to temperature changes. Source 37 is controlled so that *variable* current and

voltage can subsist between target cathode *second RF cathode electrode* 15 and a *first substrate holder that positions the substrate in the reaction zone while supporting the substrate atop a first RF anode electrode* 16. DC sources 25 and 37 are utilized for targets *second RF cathode electrode 15* made of magnetic or non-magnetic electrically conductive material. If, however, target *second RF cathode electrode 15* is made of a dielectric material, source 37 is an RF source, while source 25 remains a DC source. In addition, according to DETD(13), CPU *computer* 57 includes a conventional memory for storing a program and predetermined data for controlling the operation of sources 25 and 37, as well as orifice 32. CPU 57 is responsive to signals indicative of the desired voltage to be applied by source 37 between electrodes *second RF cathode electrode 15* and 16 and for the current to be supplied by source 37 between electrodes *second RF cathode electrode 15* and 16, as well as a desired value for the pressure in processing volume 13. The desired values for the voltage and current of source 37 and the pressure in volume 13 can be preset by an operator to initial values, or can be derived from the operator setting a desired rate of deposition for material from target cathode *second RF cathode electrode 15* to substrate 14. The set values for the voltage and current of source 37 and the *pressure* of processing volume 13 can be changed from time to time by the operator. The programmed values for the voltage and current of source 37 and the *pressure* in volume 13 are stored in the memory of CPU 57.

Boys et al do not describe all of the limitations set forth in claims 11, however, with the Salimian et al plasma-assisted CVD apparatus as a footing, one of ordinary skill in the art at the time the

invention was made would consider the pressure control system as described by Boys et al to be an obvious extension to the Patrick et al control system and impedance data collection and processing. Motivation for combining the above references follows from the desire to control plasma process attributes as discussed by the motivational statements of the references incorporated in this office action. As example, Patrick et al provide rational for influencing control over plasma process parameters with impedance measurements(column 3, lines 64-68 through column 4, lines 18).

7. Claim 21 is rejected under 35 U.S.C. 103(a) as being unpatentable over Salimian et al (U.S.Pat. 5,656,123) as applied to claims 11-14,3,4,6,16-23 above, and further in view of Grewal et al (U.S. Pat. 5,597,438). Grewal et al describes a three electrode etching chamber for selective and plasma processing of polycrystalline silicon (column 1, lines 1-12). Specifically, Grewal et al discusses:

xiii. A process chamber (item 30, Figure 2) for processing a semiconductor substrate (column 1, lines 1-12) in a plasma (column 1, lines 40-55) where the chamber consists of ...

xiv. A primary electrode (item 36, Figure 2; column 3, lines 3-25) on the ceiling of the process chamber which supports an electrically conducting surface ("electrode", column 3, line 5) exposed to the plasma zone

xv. A secondary electrode (item 42 Figure 2; column 3,lines 3-25) comprising a conductor element having a surface exposed to the plasma and absent an insulator shield. The secondary electrode is, additionally, below a third power electrode (item 48,Figure 2; column 3,lines 3-25).

xvi. An electrode voltage supply adapted to maintain the power electrode, primary electrode, and secondary electrode at one or more different electrical potentials, thus *all power supplies are electrically* *coupled and controlled independently*, due to the three independently controlled power sources (column 3,lines 3-25). Floating electrical potentials for the secondary electrode is implicit considering the range of possible values the voltages may have depending on process conditions and set points. Each of the electrode voltage supplies are adapted to maintain the ceiling and the electrode at different electrical potentials.

It is the examiner's position that a person of ordinary skill in the art at the time the invention was made would have found it obvious to modify the Salimian et al plasma processing reactor by implementing the independent source control as taught by Grewel at al to provide increased plasma volume geometric control (anisotropic) as discussed by Grewal et al (column 2, lines 5-20)

Conclusion

8. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the

THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

9. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Examiner Rudy Zervigon whose telephone number is (703) 305-1351. The examiner can normally be reached on a Monday through Thursday schedule from 8am through 7pm. The official AF fax phone number for the 1763 art unit is (703) 305-3599. Any Inquiry of a general nature or relating to the status of this application or proceeding should be directed to the Chemical and Materials Engineering art unit receptionist at (703) 308-0661.